SOME NOTES ON THE BIOLOGY AND MORPHOLOGY OF THE IMMATURE STAGES OF *HARPOBITTACUS TILLYARDI* (ORDER MECOPTERA).

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(*Communicated by Dr. R. J. Tillyard.*)

(Plate iv; thirteen Text-figures.)

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Introduction.

The adult scorpion-fly *Harpobittacus tillyardi* E.P. is a fairly common insect in many Australian localities, but so far nothing has been known concerning any immature stage with the exception of the egg.

A female captured in hill country near Canberra laid 35 eggs on 7th January, 1930, these being placed in jars to await hatching. About the middle of February—no sign of hatching having been shown—some of the eggs were soaked in water and placed on moist sphagnum moss, some were kept in petri dishes in a moist atmosphere, and some were kept dry.

Early in April many of the eggs which had been kept moist were found to have hatched out during the writer's absence from the laboratory, and the larvae had died. One more larva hatched on 20th April, and this was fed through to the 3rd instar. The eggs which had been kept dry did not hatch.

Profiting from the former experience, eggs laid by a female on 23rd January, 1931, were kept in a moist atmosphere on damp filter paper, and hatching commenced on 7th March. The larvae thus secured were reared through to the adult stage, and the material for this paper is mainly the result of observations of their behaviour and characteristics.

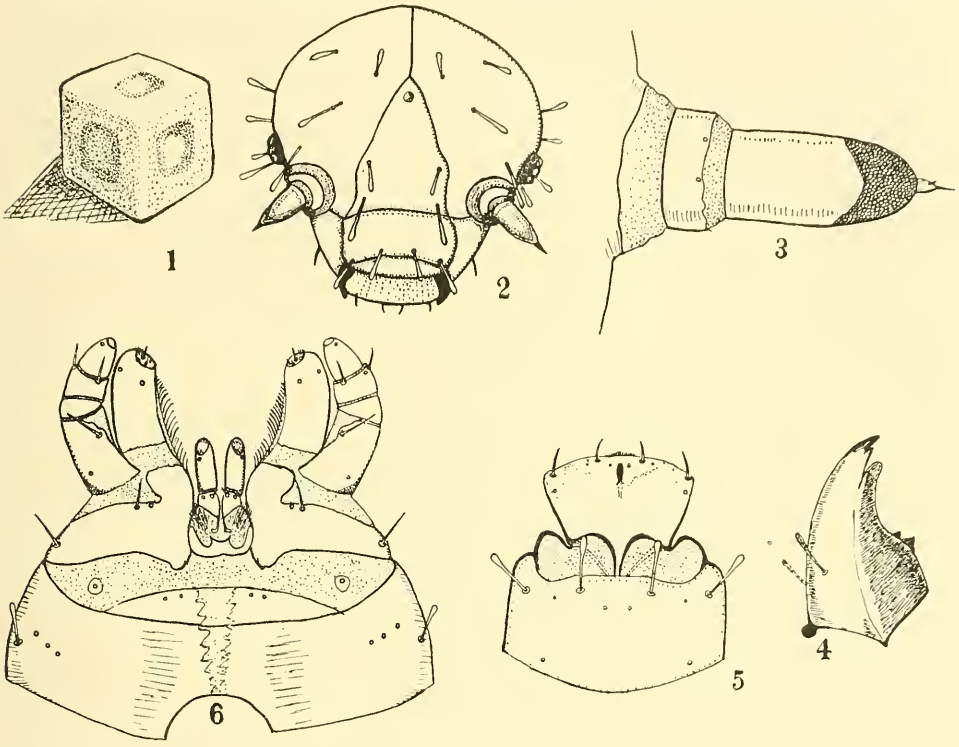
Description of Stages.

The Egg.—The egg (Fig. 1) is cuboid, grey-black in colour and measures about 0·55 mm. along its edges. The outer surface is formed of closely packed pigmented granules, which give it a rough appearance. The faces are somewhat concave when the egg is newly laid, and while dry, but as development of the embryo progresses in the presence of moisture, the egg becomes inflated to form a sphere which measures from 1·1 mm. to 1·2 mm. in diameter.

The Larva.—There are four larval instars, each stage differing from the former in point of total size and in the relative size of various parts, but differing little in structure. A general description of the larva, covering in essentials the four instars, will therefore be given.

The head is dark brown, small in comparison with the body and of general outline as illustrated in Fig. 2. The eyes consist of seven ocelli grouped together

on a prominence, three larger ocelli on the dorsal side and four slightly smaller on the ventral side. This close grouping of the seven ocelli to form a compact unit is in sharp contrast with the widely separated ocelli in caterpillars. There is a median ocellus placed on the frons just below the junction of the occipital stem and the lateral sutures. The antennae are short and stout, pointed and with



Text-figs. 1-6.
1.—Egg of *Harpobittacus tillyardi* E.P., × 20. 2.—Head of 4th instar larva, × 13.
3.—Antenna, × 1,000. 4.—Mandible, × 50. 5.—Labrum, × 47. 6.—Labium, × 56.

three joints. They are remarkable for the great development of pits on the second segment (Fig. 3). The mandibles (Fig. 4) are strongly chitinized and powerful, adapted to tearing the food.

The following table shows the length of the body and width of the head capsule (before moulting) of the four larval instars:

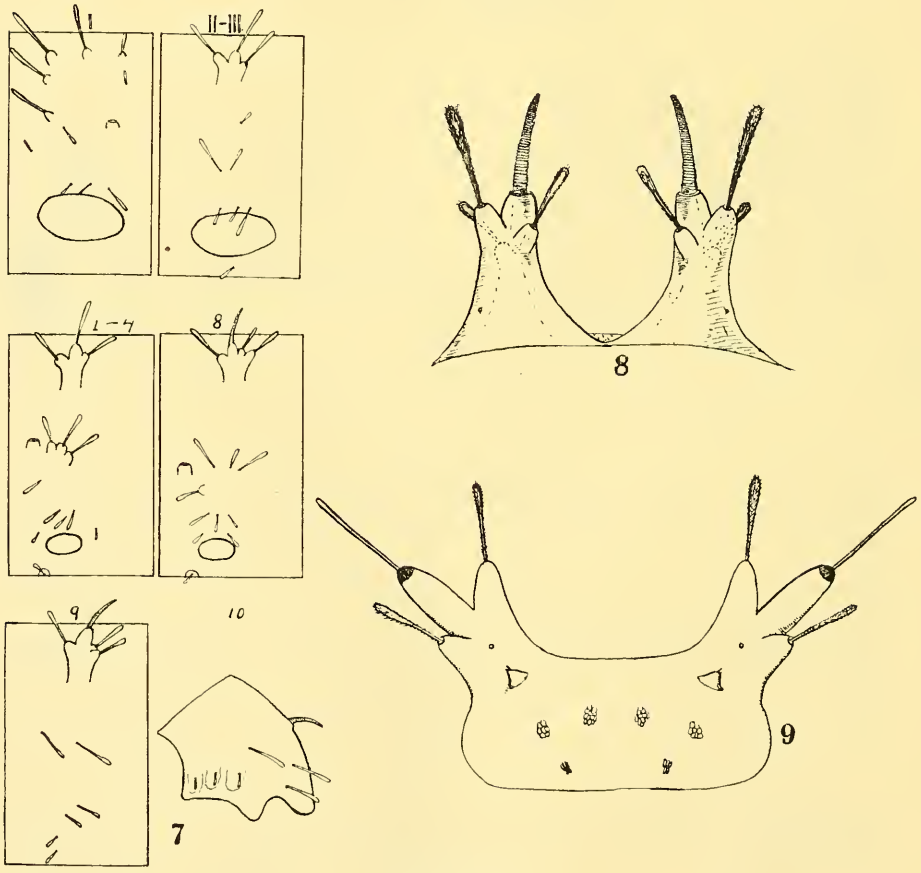
	Width of Head Capsule.	*Length of Body.*
1st instar	0·6 mm.	3.4 mm.
2nd instar	0·9 mm.	10·0 mm.
3rd instar	1·2 mm.	15·0 mm.
4th instar	1·8 mm.	21·0 mm.

The details of the labrum and labium are shown in Figs. 5 and 6 respectively.

The setae on the head and body are mostly clubbed, both stems and swollen ends being hollow. In most cases these setae rise from fleshy protuberances, and the rows of these along each side of the mid-dorsal line, and the middle of the sides, give the larva a somewhat hexagonal appearance. Walking legs of

simple pointed form are present on the three thoracic segments, and larvapods of similar structure, but somewhat smaller size, are present on abdominal segments 1–8 inclusive. There are no crochets on these larvapods. The last abdominal segment carries a trilobed, fleshy, protrusible sucker, which anchors the posterior part of the body, and aids in locomotion.

The setal maps (Fig. 7) are given so that homologies with the distribution of setae on other larvae can be worked out if desired. No suggestions are being put forward now although many similarities to setal distribution in lepidopterous larvae will be seen. Segments eight and nine both bear a pair of annulated setae quite different from the others, and a single, unpaired annulated seta is present in the middle of the dorsum of segment ten (Fig. 8). In *Chorista* the annulated type of seta is the rule, and it may be that it is the more primitive type, which in *Harpobittacus* is being slowly replaced from the head backwards by the hollow, clubbed type of seta.



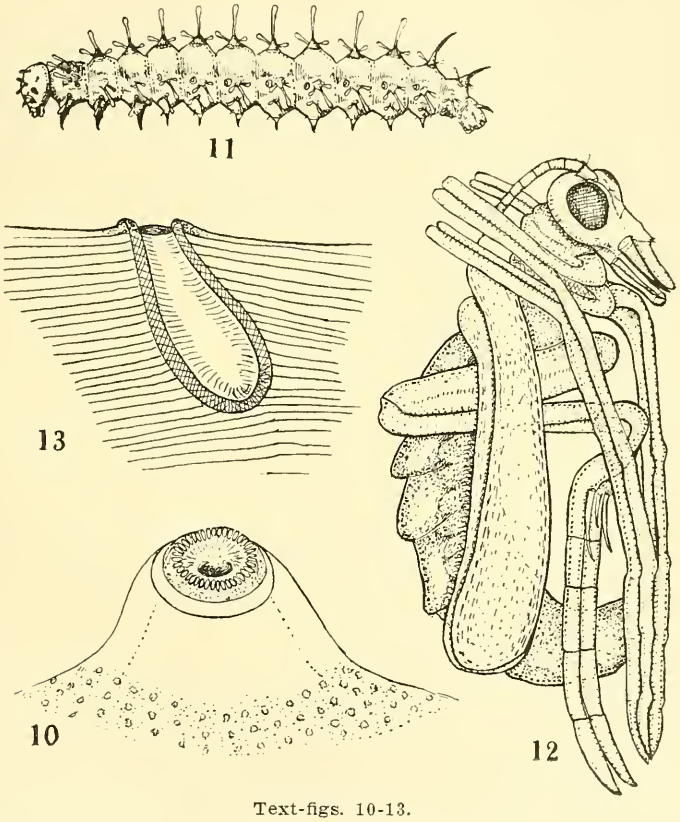
Text-figs. 7-9.

7.—Setal maps of 4th instar larva. I-III, segments of thorax; 1-10, segments of abdomen. 8.—Setae on dorsum of 8th abdominal segment, × 30. 9.—Tergum of 3rd abdominal segment, × 21.

Some details of the skin, and of the peculiar compound pore-like structures on the basal plates of the setae can be seen in the accompanying figures (Figs. 8 and 9), but as yet no attempt has been made to discover the significance of these structures.

Spiracles are present in the first thoracic segment and in segments 1 to 8 of the abdomen. They are conspicuous structures raised on a prominence. The details of their structure can be seen in Figure 10 while their distribution is shown in Figure 11.

The general shape of the larva can be seen in Figure 11 and in Plate iv which also clearly illustrates the fleshy tubercles, the rough skin covered with sand, and the two types of setae.



Text-figs. 10-13.
10.—Thoracic spiracle, × 1,500. 11.—4th instar larva, × 3. 12.—Pupa, × 6.
13.—Earthen cell in ground, × 1·5.

The Pupa.—The pupa (Fig. 12) is of the exarate type, of a greyish-white colour with brown patches on the sides of the abdomen. The illustration gives an idea of the relations of the various parts.

The Adult.—As the adult insect is fairly well known and illustrated there is no need to include a description here. The accompanying photographs show the adult in characteristic poses (Plate iv, figs. 5, 6).

Life History.

The adults appear from October to February, in the Federal Capital Territory, and seem to be somewhat local in their distribution, being associated most often with moist situations if not actually running streams. They feed on many types of insects, including beetles, bees, flies, bugs, and caterpillars, but they seem to favour most, soft-bodied insects such as tipulids of the genus *Macromastix*. They often catch their prey while crawling over blossoms and have been seen picking larvae of *Paropsis* from leaves in order to feed on them. *Harpobittacus* always eats its prey while hanging from a twig: it holds the insect to its mouth, sucks the juices and soft tissues, then drops the empty chitinous shell. The adults have been seen to suck nectar from flowers, as the accompanying photograph shows (Plate iv, fig. 6).*

Although not powerful on the wing the adults fly freely, and on warm days they may be found flying in shady places, in search of mates or prey. Mating takes place while the insects hang suspended, with ventral surfaces apposed.

The eggs, which may be laid at any time during the summer months, appear to be scattered promiscuously over the ground in moist places. If the eggs become desiccated, hatching may be delayed, though how long they can resist desiccation has not been ascertained. The eggs are at first somewhat cubical, with slightly concave surfaces, becoming inflated a few days before hatching by the absorption of water. The amount of water absorbed may be judged by the difference in weight, as follows:

Weight of 8 eggs uninflated	0·0019 gr.
„ „ „ inflated with water	0·0054 gr.

Eggs laid on 23rd January and kept moist began to hatch on 7th March, and the last egg hatched on 4th April—the period ranging from 43 to 71 days.

Eggs laid on 7th January (1930) and kept dry for a period hatched in 79 to 103 days.

The larva, in hatching, emerges from the egg-shell through an irregular opening, and proceeds to feed on a portion of the shell as its first meal. Young larvae were given soil, liverwort, mosses, and dead insects, and were found to feed on the juices of the dead insects, taking an occasional bite of liverwort. Their movements are sluggish, and when disturbed they have a habit of rearing the body in a perpendicular position.

The duration of the first instar, in the laboratory, was from 4 to 7 days, with an average of 5 days. Some time before moulting the larvae were seen to swallow soil, and the significance of this appeared later.

Having ceased to feed, a larva about to moult sought a high spot, such as a liverwort leaf or a small mound of soil, and there it lay quiescent for several hours. The clubbed setae of the next larval instar could be clearly seen through the transparent skin. A forward surging of the body juices, coming spasmodically in waves, swelled out the thoracic segments. This surging ebbed and flowed a number of times before culminating in a great wave which split the prothorax along the mid-dorsal line, and allowed the emergence of the humped-up thorax of the next stage. Further tumultuous surgings split open the old head capsule, the delicate new head emerged, and the larva crawled forward out of the old skin which it devoured later.

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* Observation made by Dr. A. J. Nicholson.

After resting for about ten minutes, the larva was seen to lift up its anal extremity and to carry it forward over the dorsum until the anus rested on the top of the head capsule. A stream of sand particles in a glutinous fluid was then poured from the anus, while the anal extremity was passed backwards with a brushing motion, bespattering the whole length of the dorsum with sand. After an interval of about twenty minutes this process was repeated, and after the back had been thoroughly covered with sand, from end to end, the sides were similarly treated: the whole process lasted for about two hours. When dry the sand stuck firmly to the skin, appearing to be fixed with some cement, and could not be removed without great difficulty (Pl. iv, fig. 2). This covering of the back and sides was repeated after each moult, with the result that the larva, covered with the soil in which it lived, became very inconspicuous, and so protectively disguised. The gut having been thus emptied after a moult, this process was not repeated until after the next moult.

In order to discover if the soil-swallowing habit had any relation to digestion, several larvae were fed on insects only, with no access to soil. These larvae grew just as rapidly, and moulted as easily as the larvae which had access to soil, and the contents of the gut (containing small pieces of chitin, etc.) were voided on the dorsum as in the case of the others.

As a control experiment in connection with the soil-eating habit, some larvae were given soil stained with methylene-blue, others soil mixed with carmine powder, still others clean white sand, and dark sand. Larvae blue, red, white and black were thus obtained, and it was easy to see through the transparent skin when a soil meal had been taken, and to trace its fate.

The main diet of the larvae consisted of dead blowflies, which were easily obtainable. They would not attack a live insect, but started away from any moving object. In feeding, they sucked and scooped all the softer parts out of the chitinous shell, which was left behind.

The larvae could not live long in a dry atmosphere, so had to be reared in glass vessels with moist filter paper covering the bottom, or on moist soil. Sometimes the hollow setae were seen to have drops of moisture at their tips: this may be due to some hygroscopic quality or may be a device for getting rid of surplus moisture from the body. If kept in a dry atmosphere the normally moist skin becomes dry, and the larva then has the peculiar faculty of flushing the skin with moisture. This moisture appears first just behind the head, and passes rapidly backwards over the thoracic and abdominal segments. After a time the larva becomes unable thus to flush the whole skin surface with moisture, and the moistened area becomes restricted to the thoracic segments, and finally to a small area on the prothorax. When kept for about a day in a warm, dry atmosphere, the larva usually succumbs.

The duration of the four larval instars in the laboratory was as follows:

1st instar	4 to 8 days	average	5
2nd instar	5 to 7 days	,,	6
3rd instar	6 to 11 days	,,	8½
4th instar (to entering soil)	12 to 17 days	,,	14
Resting larva in earthen cell	about 160 days		
Pupa to adult	14 to 50 days		

The fourth instar larva, on becoming full-fed, begins to dig a hole in the soil, pressing the earth into the sides and cementing it in position with saliva. An earthen cell is thus formed (Fig. 13) and a lid is made by the larva which

then lies head upwards in the cell, and shrinks in size. The winter is passed as a prepupal larva, until, as the weather warms up in spring, the insect pupates and emerges later as an adult. In some cases, in the laboratory, the third instar larvae began to dig as the weather got cool in late March and April. The earthen cocoons were formed, the larvae passed the winter therein, and emerged in spring to recommence feeding. Only a few larvae behaved in this manner, and none of these succeeded in reaching the fourth instar. One larva in its earthen cell was kept for four months at a temperature of 80° F., but its pupation was hastened only by about three weeks.

It is hoped that if time and opportunity offer, further work will be done on the biology of this most interesting and primitive insect, and that meanwhile these notes will be of value in adding to our knowledge of the Australian Mecoptera.

Acknowledgments.

Thanks are due to Dr. R. J. Tillyard who drew the author's attention in the first place to the meagreness of our knowledge concerning the immature stages of the scorpion-flies, and whose unflagging interest was always stimulating; to Dr. A. J. Nicholson who loaned the photographs of adult insects on Plate iv, and to Mr. J. W. Evans for helpful suggestions in the preparation of the manuscript.

EXPLANATION OF PLATE IV.

Fig. 1.—Side view of 4th instar larva. Fig. 2.—Back of larva showing skin covered with sand. Much enlarged. Fig. 3.—Portion of back of larva showing two types of setae. Fig. 4.—Back and side view of larvae. Fig. 5.—Adult feeding on fly. Fig. 6.—Adult searching flowers for nectar.